Office of Operating Experience Analysis, EH-33 • U.S. Department of Energy • Washington, D.C. 20585

OPERATING EXPERIENCE WEEKLY SUMMARY

Office of Nuclear and Facility Safety

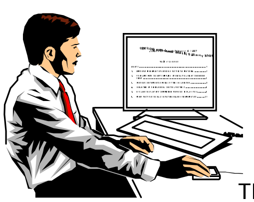
February 6 through February 12, 1998

Summary 98-06

Operating Experience Weekly Summary 98-06

February 6 through February 12, 1998

Table of Contents



Visit Our Web Site

The Weekly Summary is available, with word search capability, via the Internet at http://tis.eh.doe.gov/web/oeaf/oe_weekly/oe_weekly.html. If you have difficulty accessing the Weekly Summary at this URL, please contact the ES&H Information Center, 1-800-473-4375 for assistance. If you have additional pertinent information or identify inaccurate statements in the summary, please bring this to the attention of Jim Snell, 301-903-4094, or Internet address jim.snell@hq.doe.gov, so we may issue a correction.

EVENTS

1. LOSS OF ACCOUNTABILITY OF A SEALED SOURCE

On February 4, 1998, at the Rocky Flats Environmental Technology Site, a facility manager reported loss of accountability of a sealed, 150 mCi tritium source contained in an electron-capture detector and installed in a gas chromatograph. Property utilization and disposal personnel received the gas chromatograph from the plutonium manufacturing and assembly complex, opened it, discovered the source, and notified radiological control personnel because they recognized the trefoil symbol. The lack of accountability and monitoring of sealed sources can result in lost sources, improperly discarded sources, and failed source integrity and can lead to the spread of contamination and personnel exposure. (ORPS Report RFO--KHLL-FACOPS-1998-0002)

Investigators believe that when site personnel received the gas chromatograph from the manufacturer in the late 1980s they were unaware that it contained a sealed source, so it was not registered with the Rocky Flats source registrar. Investigators are continuing to review this event and evaluate approximately 58 additional on-site gas chromatographs for compliance to accountability and monitoring requirements.

NFS reported radioactive source accountability problems in several Weekly Summaries. Following are some examples.

- Weekly Summary 97-34 reported that a facility manager at the Sandia National Laboratory discovered that a gas chromatograph containing a 150 mCi tritium source was not registered in the site source registry. Investigators determined that a source custodian did not register it when it was received from the manufacturer, resulting in a loss of accountability of the sealed source. (ORPS Report ALO-KO-SNL-6000-1997-0007)

- Weekly Summary 94-24 reported that personnel at the Hanford Site discovered a cesium-137 source that was not on their sealed radioactive source accountability list. The source was part of a nuclear liquid-level measuring instrument that contained 10 µCi of cesium-137. Health physics technicians established proper control of the source. (ORPS Report RL--WHC-GENERAL-1994-0008)

- Weekly Summary 94-22 reported that radiation control personnel at the Sandia National Laboratory found four radioactive sources that were not entered into the source accountability system. A promethium source, measuring 460 mrem/hr beta on contact, was inside a measurement device without a shield in place to prevent exposure. The other three sources were sealed and measured 86 mrem/hr beta on contact. Investigators determined that Sandia personnel lost track of the four sources because they were not entered into the radioactive source accountability system. (ORPS Report ALO-KO-SNL-1000MDL-1994-0002)

- Weekly Summary 93-20 reported that health physics personnel at the Savannah River Site discovered an ion chamber with a sealed 85-µCi source in a dumpster at the Vitrification Facility. They were conducting a search for previously exempted sources that were no longer exempt and required accountability. When health physics personnel searched other areas of the facility, they found three more sources. (ORPS Report SR--WSRC-WVIT-1993-0036)

Some of the corrective actions for these events involved training personnel on source control, source registration, and facility documentation. Facility documents were also revised, in some cases, to include guidance on the procurement, registration, storage, use, and disposal of radioactive sources.

Certain manufactured devices can contain radioactive sealed sources. DOE facilities routinely use some of these devices, such as gas chromatographs, level measuring devices, film-thickness gages, or radiography devices. Many of these devices are registered by the manufacturer under a general Nuclear Regulatory Commission (NRC) license or an Agreement State license and may not require a site-specific license. However, these devices must be tracked in the site registry unless they meet the exemption requirements contained in DOE N 441.3, *Radiological Protection for DOE Activities*. The NRC requires the manufacturer to provide documentation to the user stating that the device contains a sealed radioactive source. Following is a general list of device categories that may contain sealed sources. The list includes descriptions of typical uses and examples of specific equipment that usually contains sealed sources.

- Industrial Radiography Devices—Radiography uses a gamma-emitting source to detect cracks or defects in structural material such as cement, steel reinforcing beams, and welded joints. The radiography camera typically contains a sealed source of iridium, cobalt, or cesium.

- Gamma Irradiators—This process uses irradiators to bombard an object with radiation to bring about a desired change. Irradiators fall into two general categories: dry storage irradiators, which are typically used in medical applications; and wet storage irradiators, which are typically used in industrial applications. Irradiators usually contain a cobalt sealed source.

- X-ray Fluorescence Analyzers—This process uses x-rays given off from irradiated samples to perform various analyses. This equipment can be used to detect cracks, imperfections, content, or age. X-ray fluorescence analyzers usually contain an iron, cadmium, or americium sealed source.

- Content Analysis Devices—This process uses thermal neutron activation to determine the content of certain substances in a sample. This equipment usually contains a sealed source of californium, a tritium/deuterium mixture, or an americium/beryllium mixture. These devices are used in three main applications: (1) well-logging, (2) general content analysis, and (3) explosive detection systems.

- Beta Backscatter Gages—These gages are usually hand-held devices used to determine material properties, such as thickness or density, using an americium sealed source. These gages are typically used in road construction.

- Transmission Gages—These gages are used in a wide variety of applications for measuring bulk density or weight, monitoring moisture content or tank level, or measuring material thickness. The gages can contain cesium, cobalt, krypton, strontium, or americium sealed sources. Other types of gages that fall into this category are level gages, variable reading gages, and thickness gages.

- Ionizers—Ionizers contain ionized air or gas to perform specific functions. These include gas chromatographs, smoke detectors, static eliminators, and static monitors. These devices usually contain nickel, tritium, americium, or polonium sealed sources.

- Self-luminous Devices—These devices are used to create light without outside activation and include exit signs, gun sights, watch dials, instrument panel dials, and entry-lock lights. The devices usually contain tritium but may also contain krypton, carbon, or promethium sealed sources.

These events emphasize the importance of strict accountability of radioactive sources and demonstrate the need for a strong radioactive source control program. Sealed source accountability programs should include consideration of potential hazards associated with environmental and operating conditions such as temperature, corrosive atmosphere, or vibration to ensure sealed sources conform to American National Standard (ANSI) N542 classifications. In addition, DOE maintains a regulatory position paper on sealed radioactive source controls that delineates proposed requirements similar to those of the NRC. The position paper states that “these requirements were determined to be necessary for an adequate radiation protection program.” Personnel responsible for radioactive source control at DOE facilities should ensure their source control program includes the following elements from DOE N 441.1 through DOE N 441.3.

- administrative procedures for the control of accountable sealed radioactive sources

- labels on all accountable sources (or their storage containers or devices) with the standard radiation warning trefoil and the words, "Caution, Radioactive Material"

- an individual designated to maintain control of assigned accountable sources (The individual shall be trained as a radiological worker in accordance with 10 CFR 835.902 and instructed on site-specific source control procedures.)

- periodic inventory of each accountable source at intervals not to exceed 6 months (The inventory should verify (1) physical location of each source, (2) adequacy of postings and labels, and (3) adequacy of storage locations, containers, and devices.)

- integrity testing of each source (with an activity exceeding 0.005 µCi) upon receipt, when damage is suspected, and at intervals not to exceed 6 months

DOE N 441.3, *Radiological Protection for DOE Activities*, requires control and accountability of sealed radioactive sources. However, this notice applies only to defense nuclear facilities. The majority of pertinent radiological protection requirements have become codified through promulgation of 10 CFR 835, *Occupational Radiation Protection*. However, 10 CFR 835 currently does not address sealed radioactive source accountability; source accountability will be addressed in a pending amendment. Facility managers should refer to DOE/EH-256T, *Radiological Control Manual,* for information on the control and accountability of sealed radioactive sources.

DOE Implementation Guide G-N 5400.9/M1-Rev.1, *Sealed Radioactive Source Accountability and Control*, provides guidance for establishing and operating a sealed source accountability and control program. Specific guidance includes organization and responsibilities, receipt, labeling and storage, inventory, integrity testing, and handling and disposal.

ANSI N542, *Sealed Radioactive Sources, Classification*, section 4.2, states that a sealed source manufacturer and user must consider the impact of fires, explosions, and corrosion on the source as well as the potential results. Factors to be considered include (1) consequences of activity loss, (2) quantity of material, (3) radiotoxicity, (4) form and geometric shape of the source, (5) environment, and (6) any protection of the source.

Links to DOE radiation protection documents, including the sealed source position paper, can be found at URL http://tis-nt.eh.doe.gov/wpphm/regs/regs.htm. The NRC maintains a sealed source database. The database can be found at URL http://www.NRC.gov/NRC/FEDWORKD/NRC-SSD/index.html. This database provides a list of sealed sources licensed by the NRC and a variety of information on sealed sources. Ordering information for ANSI documents can be obtained through the ES&H Information Center navigation map at URL http://www.eh.tis.doe.gov/map.html.

KEYWORDS: sealed source, accountability, radiation protection

FUNCTIONAL AREAS: Radiation Protection

2. INADEQUATE LOCKOUT OF ELECTRICAL POWER SOURCE

On February 5, 1998, at the Savannah River In-Tank Precipitation Facility, a work group supervisor conducting a walk-down of a lockout installation discovered that operators had incorrectly locked and tagged the source of electrical power to a multiplexor cabinet. Operators were supposed to remove a plug that supplied 120-volt ac power to the multiplexor cabinet transformer from the multiplexor Uninterruptible Power Supply (UPS), but instead they unplugged the power source for the UPS. As a result, the UPS battery continued to supply 120 volts to the transformer. Although the battery in the UPS had a 10-minute rating and had dissipated power by the time the incorrect lockout was discovered, the inadequate lockout resulted in a potential electrical safety hazard. (ORPS Report SR--WSRC-ITP-1998-0012)

On February 4, engineering personnel, maintenance personnel, and operations supervisors reviewed the lockout in preparation for its installation. On February 5, the facility shift manager authorized installation of the lockout, operators installed and verified it, and the shift manager signed the lockout as "established." The work group supervisor then signed the lockout and conducted a safety walk-down to ensure it was safe for maintenance personnel to inspect the transformer for a potential ground problem. During the walk-down he determined that the lockout had been improperly installed and informed the shift manager of his findings. The shift manager stopped the work.

Investigators determined that the lockout installation was independently verified. However, both the installer and verifier stated that the plug they pulled was the one that they had always pulled before. The plug they pulled was labeled “UPS POWER”; the other plug was not labeled. Investigators also determined that maintenance workers planned to perform a zero-energy check before beginning the work. This would have verified the no-voltage status, but would not have identified the inadequate lockout unless the battery had not dissipated and was still providing voltage. Investigators continue to look at other weaknesses in the preparation of the lockout that may have contributed to this event (e.g., unclear instructions on the lockout points; no walk-down by the lockout preparer).

NFS has reported numerous lockout/tagout events in the Weekly Summary. The following are examples of inadequate lockouts of electrical sources.

- Weekly Summary 97-40 reported that an electrician at the Oak Ridge National Laboratory received an electrical shock and minor burn when he touched an energized 480-volt incoming feed in a switchgear. Investigators determined that operators installed an inadequate lockout/tagout because the lockout preparer failed to identify a second source of power to the switchgear. The electrician also failed to perform a zero-energy check. (ORPS Report ORO--ORNL-X10HFIR-1997-0016)

- Weekly Summary 97-31 reported that a mechanic at the Savannah River Site installed a lockout to de-energize a 480-volt electrical source to troubleshoot and repair an air conditioning system. While the mechanic was working on the system, an auditor discovered that the cabinet contained an energized 120-volt electrical feed in addition to the 480-volt source. Investigators determined that the lockout preparer failed to thoroughly research the isolation boundaries. (ORPS Report SR--WSRC-TNX-1997-0005)

These events underscore the importance of the lockout/tagout preparer’s role in writing clear and concise lockout orders. Preparers should review up-to-date drawings and enlist the support of subject matter experts as necessary. They should also walk down the system to identify potential hazards and verify that the lockout can be performed correctly based on equipment location, proper labeling, and procedures. Walk-downs can also aid in verifying the accuracy of drawings used in establishing isolation boundaries. The work group supervisor’s attentiveness during his walk-down identified an inadequate lockout that otherwise may have gone undetected, resulting in its recurrence.

DOE-STD-1030-96, *Guide to Good Practices for Lockouts and Tagouts*, provides guidance on lockout/tagout program implementation and management at DOE facilities. Section 4.4, “Procedures for Lockout/Tagout,” states that procedures should identify the locations for all tags, the order of operation and tagging, and the final position of the tagged components. Procedures should also provide specific instructions for placing and removing locks and tags and clear instructions for verifying the effectiveness of the lockout/tagout. Section 4.5.1, “Installation of Lockout/Tagout,” states that a qualified person should verify isolating and de-energizing the equipment and installation of the locks and tags. Guidance for performing verifications can be found in DOE-STD-1036-93, *Guide to Good Practices for Independent Verification*, and DOE/EH-0502, Safety Notice 95-02, “Independent Verification and Self-Checking.” In addition, the adequacy of the protection should be verified by the individual(s) or work group representative(s) who will be working under the lockout/tagout. Verification of electrical systems should include checking that the system shows no voltage.

Facility managers should review DOE/EH-0540, Safety Notice No. 96-05, "Lockout/Tagout Programs.” The notice summarizes lockout/tagout events at DOE facilities, provides lessons learned and recommended practices, and identifies lockout/tagout program requirements. The *Hazard and Barrier Analysis Guide*, developed by OEAF, includes a hazard-barrier matrix showing that lockout/tagout is the most effective barrier against injury. When implemented properly, lockout/tagout provides a high probability (greater than 99 percent) of success for risk reduction.

DOE 5480.19, *Conduct of Operations Requirements for DOE Facilities*, chapter IX, “Lockouts and Tagouts,” provides guidelines for lockout/tagout use and implementation. Chapter XVIII, “Equipment and Piping Labeling,” provides guidelines for equipment and component labeling and states that equipment labeling should help ensure that facility personnel are able to positively identify equipment they operate. Labeling is also required by OSHA regulations.

Safety Notices 95-02 and 96-05 can be obtained by contacting the ES&H Information Center, (800)473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Road, Germantown, MD 20874. Safety Notices are also available by accessing the OEAF Home Page at http://tis.eh.doe.gov:80/web/oeaf/lessons_learned/ons/ons.html. A copy of the *Hazard and Barrier Analysis Guide* is available from Jim Snell, (301) 903-4094, and may also be obtained by contacting the ES&H Information Center.

KEYWORDS: lockout and tagout, maintenance, operations

FUNCTIONAL AREAS: Operations, Electrical Maintenance, Work Planning

3. FLAMMABILITY MONITOR UNCERTAINTY CALCULATIONS AFFECTED BY TEMPERATURE

On February 3, 1998, at the Savannah River In-Tank Precipitation Facility, the facility manager reported that the instrument uncertainty calculation for Composite Lower Flammability Limit (CLFL) monitors for two process tanks did not account for the full range of operating temperatures to which the equipment would be exposed. The facility operational safety requirements assume a 12 percent instrument uncertainty for the CLFL tank monitors. This value is based on a supporting calculation assumption that the temperature of the instrument is maintained between 90 and 130 degrees Fahrenheit. However, the uncertainty calculation did not account for the difference between the temperature at which the equipment was calibrated (ambient) and the expected operating temperatures. As a result, engineers determined the actual uncertainty was much greater than the uncertainty assumed in the operational safety requirements. Investigators determined that reviews of facility operational and technical safety requirements failed to identify operational conditions that could affect CLFL monitor indications and uncertainty calculations. This event is significant because monitors installed to detect and alert personnel of the buildup of flammable mixtures in these tanks may not be calibrated properly and the instrument uncertainty may allow a higher than acceptable CLFL percentage in the tanks. (ORPS Report SR--WSRC-ITP-1998-0011)

On January 29, facility engineers notified the facility shift manager that the CLFL monitor calibrations were indeterminate. He declared the monitors inoperable and directed operators to perform manual explosion monitoring of the tanks in accordance with the operational safety requirements. On February 3, engineers notified the facility shift manager that the instrument uncertainty was greater than expected. Engineering reviews of this problem followed other recent events at the facility. These events included CLFL analyzer transmitters that flashed negative zero on the remote digital indication (ORPS Reports SR--WSRC-ITP-1998-0009 and 0010) and low monitor sample flows caused by a buildup of moisture because the cabinet heater was not operating (ORPS Reports SR--WSRC-ITP-1998-0001 and 0007).

The CLFL monitors are installed in cabinets at the tanks. The sensing lines for the monitors are heat-traced, and the cabinet contains an electric heater to maintain temperatures around 100 degrees Fahrenheit. These conditions were assumed to be continuous in the uncertainty calculations. Facility personnel open the cabinet to inspect and calibrate the monitor, thus allowing temperatures to approach ambient conditions. If the heat-tracing or the cabinet heater fail, the temperature of the cabinet and monitor may be affected. Investigators determined that the heaters and heat-tracing do not have a safety classification that requires the level of maintenance rigor or surveillance that is needed to ensure their availability. Investigators also determined that, based on continuing evaluations, there appears to be no operational safety requirement impact on other facility tanks. However, the evaluation is incomplete, and there may be additional instrument impacts.

NFS reported on a similar issue in Weekly Summary 97-35 where a hydrogen sensor installed in a portable exhauster used for core-sampling flammable gas tanks at the Hanford Tank Farms had inconsistent sensor calibration results and failed to meet response time requirements. The hydrogen sensor is an electro-chemical cell installed in the flow stream of the exhauster. The sensor initiates alarms and shuts down the core-sampling system when it detects a hydrogen release in the tank. The sensor was not installed in a climate-controlled enclosure, and ambient temperature during the calibration was 20 to 30 degrees Fahrenheit. The manufacturer’s specifications for the sensor required operating temperatures of 70 to 120 degrees Fahrenheit. Investigators determined that inadequate system design and design reviews resulted in the installation of equipment that could not reliably perform its safety function at low ambient temperatures. The direct cause of the deficiencies was inadequate design because the functional design criteria required the system to operate in a -20 to 115-degree Fahrenheit environment, which was lower than the vendor’s specifications. The system design did not provide thermal protection for the sensor. One of the corrective actions included a second formal design verification on all safety class components of the exhauster and exhauster interlock system. This activity included preparing a design review plan, a design compliance matrix to cross-reference and verify all design criteria against design attributes, and a system-specific design review checklist. (ORPS Report RL--PHMC-TANKFARM-1996-0025)

This event illustrates the importance of having a mechanism in place to ensure that assumptions made in the facility operational and technical safety requirements consider operational conditions of equipment installed in the field. Taking credit for maintaining the CLFL monitors in a temperature-controlled environment as part of the uncertainty calculations should have identified a need to consider operational conditions (e.g., inspection, calibration, and system failures) that could affect instrument operation. Periodic reviews of safety documentation should focus on earlier assumptions to ensure they remain valid under all conditions. DOE O 5480.23, *Nuclear Safety Analysis Reports*, requires contractors to review and update safety analysis reports annually.

DOE O 5480.22, *Technical Safety Requirements*, provides requirements for preparing technical safety requirements (formerly called operational safety requirements) for non-reactor nuclear facilities. Paragraph 9.b states in part: "Technical Safety Requirements shall define the operating limits and surveillance requirements, the basis thereof, safety boundaries, and management or administrative controls necessary to protect the health and safety of the public and to minimize the potential risk to workers from the uncontrolled release of radioactive or other hazardous materials and from radiation exposure due to inadvertent criticality.” Managers at DOE facilities should review their programs for establishing and maintaining authorization basis documents to ensure their compliance with the Order.

KEYWORDS: calculations, calibration, explosion, flammable, monitor, tank, operational safety requirement

FUNCTIONAL AREAS: Licensing/Compliance, Instrumentation and Control

4. INADEQUATE MAINTENANCE PROCEDURES COULD HAVE RESULTED IN THE FAILURE OF AN EXHAUST FAN BEARING

On January 20, 1998, at the Los Alamos National Laboratory, Chemistry and Metallurgy Research Facility, a facility manager determined that inadequate maintenance procedures could have resulted in the failure of an exhaust fan bearing. The failure occurred during testing of the fan after subcontractor maintenance staff replaced the bearings. Preliminary analysis of the lubricants from the failed bearing revealed that the workers may have used the wrong type of lubricant. Investigators determined that the maintenance procedures did not specify lubricant requirements and there was no formal lubrication program for the facility. These issues could have contributed to the bearing failure. This event is significant because proper lubrication is vitally important in maintaining trouble-free operation and avoiding equipment damage. (ORPS Report ALO-LA-LANL-CMR-1998-0006)

In late 1997, routine vibration checks of the fan bearings revealed that they needed to be replaced. Subcontractor maintenance staff, who had performed similar bearing replacements on other exhaust fans in the facility, performed the bearing replacement on December 19, 1997. On January 14, 1998, facility operators started the exhaust fan in slow speed for a 72-hour “break-in” run on the new bearings. After 90 minutes, a high-bearing-temperature alarm sounded, and operators observed a rapid increase in thrust bearing temperatures. The operators stopped the exhaust fan to investigate the cause of the high-temperature alarm.

Operators drew oil samples from several containers of oil that were located near the area where the maintenance staff had performed the bearing replacement to determine whether the correct oil was used for lubricating the new bearings. Initial inspection of the oil samples led the operators to believe that maintenance personnel could have used the wrong oil to lubricate the bearings. The operators notified the facility manager of the problem, but did not sample the oil from the suspect bearings. On January 15, the facility manager convened a critique to discuss the bearing replacement work. Critique members determined that the following issues were relevant to replacement and lubrication of the fan bearings.

- The work package did not specify the type of lubricant to use for the bearings and did not contain any manufacturer's specification sheets for the bearings or the fan.
- Neither facility operations personnel nor the subcontractor had a system to formally control the various types of lubricants used in the facility.
- Although the maintenance workers carefully aligned the bearings during installation, they did not document the alignment settings. Also, facility operations personnel did not provide any maintenance procedures that required the workers to document the alignment.

After the critique, operators drew an oil sample from the thrust bearing and submitted it for quantitative analysis to determine whether the wrong oil was used for the bearing. On January

20, the facility manager received the preliminary analysis results. The analysis revealed that the thrust bearing may not have contained the specified type of oil because the bearing oil was contaminated with solvents and other types of lubricants. The analysis also indicated the presence of metal shavings, which is indicative of bearing failure. Based on this information, the facility manager instructed the maintenance subcontractor to remove and analyze the failed bearings to determine the root cause of the failure. The facility manager also directed the following corrective actions.

- Facility operations personnel will develop corrective actions to provide work packages with sufficient content to allow maintenance personnel to properly perform their work.

- The subcontractor managers will develop corrective actions to formally control lubricants in the facility.

This event illustrates the importance of implementing a lubrication control program and using maintenance procedures that include manufacturer's requirements for lubricants and component alignments. In selecting a lubricant for a specific bearing, the equipment manufacture establishes the speed of the journal and the load. He also considers the viscosity and operating temperature so that the oil selected can carry the load imposed on the bearing at its operating temperature without a breakdown. It is the manufacturer's responsibility to recommend the proper lubricant for their machinery, but it is the responsibility of the operator to make sure that the correct lubricant is used and the bearings are properly lubricated. Contaminated oils or oils that do not have the correct properties can reduce bearing life and result in failure.

KEYWORDS: bearings, exhaust fan, lubricant, maintenance, oil, procedures

FUNCTIONAL AREAS: Mechanical Maintenance, Procedures

FINAL REPORTS

This section of the OE Weekly Summary discusses events filed as final reports in the ORPS. These events contain new or additional lessons learned that may be of interest to personnel within the DOE complex.

1. RAINWATER LEAKS INTO BREAKER AND CAUSES POWER OUTAGE

On July 29, 1997, at the Sandia National Laboratory, rainwater leaked into a breaker installed in an enclosure, causing a power outage. The rainwater entered the enclosure during a severe storm, caused the microprocessor-controlled breaker to fail, and resulted in a loss of power to a building in Tech Area I. There was no impact on environment, safety, or health as a result of this occurrence. (ORPS Report ALO-KO-SNL-NMFAC-1997-0007)

Investigators determined that a gutter diverted rainwater from the roof directly onto the breaker enclosure. They also determined that the enclosure had a National Electrical Manufacturer's Association, NEMA 12, designation, with conduit penetrations in the top of the enclosure receiving 4-inch, thin-walled metal conduit with "Meyer's Hub" connectors. NEMA publication 250, *Enclosures for Electrical Equipment*, states that the principal application for "NEMA 12" enclosures is for indoor use, where protection from dust, oil, and dripping non-corrosive liquids is required. Investigators also determined that there are no Underwriters Laboratories "rain-tight" connectors listed for 2.5-inch or greater conduit.

The facility manager implemented the following corrective actions.

- The site standards committee evaluated the use of thin-walled metal conduit in outdoor applications and will adjust the standards as necessary based on their evaluation.
- A roofing systems engineer investigated and improved rain-gutter system.

The facility manager also directed that site guidelines for installing microprocessor-controlled equipment in outdoor locations be revised to consider the following.

- The enclosure type should be rated for outdoor use.
- The enclosure should be located away from potential sources of excessive water.
- Penetrations should enter the enclosure from the sides or bottom, where possible.
- Solar heat gains should be taken into account when determining enclosure location.
- Rigid, threaded conduit should be used for conduit penetrations 2.5 inches in diameter or greater.

Water intrusion into electrical equipment can result in equipment damage, electrical outages, and disruption of facility operations. NFS has reported other water-intrusion events in Weekly Summaries. Following are some examples.

- Weekly Summary 97-32 reported that on July 27, 1997, at the Los Alamos National Laboratory, water backed up in an abandoned drain line and leaked into a 13.2-kV transfer switch at the Health Research Laboratory, causing the incoming circuit breaker in the transfer switch to short circuit and trip. The loss of power to the transfer switch caused a loss of power throughout the facility and a financial impact in excess of $40,000. Investigators determined that the drain line was capped with duct tape. (ORPS Reports ALO-LA-LANL-HRL-1997-0001, ALO-LA-LANL-TA55-1997-0032, and ALO-LA-LANL-CMR-1997-0010)

- Weekly Summary 97-25 reported that on January 10, 1997, at the Idaho National Engineering Laboratory New Waste Calcination Facility, a technician discovered that rainwater had leaked into a fire alarm panel, resulting in the failure of interior circuit boards. The fire alarm panel is safety-significant equipment designed to report system trouble to the fire department's alarm room. (ID--LITC-LANDLORD-1997-0008)

- Weekly Summary 96-24 reported that on June 6, 1996, at Oak Ridge, a 13.8-kV circuit breaker in a substation tripped because 35 gallons of water accumulated in the primary bus compartment of a transformer, resulting in a ground fault. Damage to the transformer was minimal; however, power was lost to the High Flux Isotope Reactor, the Radiochemical Engineering Development Center, and ancillary trailers. The power outage caused a reactor scram and evacuation of the Radiochemical Engineering Development Center. (ORO--ORNL-X10PLEQUIP-1996-0007)

Electric equipment designers responsible for specifying the design, type, and location of outdoor equipment should refer to the National Fire Protection Association Standard, NFPA 70*, National Electrical Code;* the National Electrical Manufacturer’s Association document*, NEMA Publication 250*, *Enclosures for Electrical Equipment;* and NEMA Standard ICS 6*, Industrial Control and Systems Enclosures.* Additional information on NEMA electrical standards is available at URL http://www.nema.org/nema/standards.

KEYWORDS: breaker, water, power outage

FUNCTIONAL AREAS: Design, Procurement

2. VENTILATION SYSTEM FAILURE

On November 18, 1997, at the Hanford Waste Sampling and Characterization Facility, a stationary operating engineer discovered that the ventilation system was not operating, leaving the north laboratory without ventilation. Investigators determined that the heating, ventilation, and air conditioning system uses two trains to supply ventilation to the laboratory rooms and that one train was shut down for maintenance when the other train failed. The cognizant engineer and an instrument technician determined that the ventilation system shut down because the air-flow sensors were plugged with grease. Investigators determined that a millwright performed preventive maintenance on the system the previous day. They also determined that he over-lubricated a supply fan bearing resulting in the excess grease splashing onto the sensors when the fan started. Loss of the ventilation system resulted in the laboratory being shut down and caused delays in work activities. (ORPS Report RL--PHMC-WSCF-1997-0007)

Investigators determined that personnel error (inattention to detail) was the direct cause of this event. They determined that the ventilation shut-down was directly caused by over-lubricating the supply fan bearings. Investigators determined that the root cause of the event was a lack of facility-specific knowledge and proficiency (i.e., skill of the craft). The millwright who over-lubricated the supply fan bearing did not have facility-specific knowledge and did not realize the implications of over-lubricating the fan bearings.

The facility manager determined that worker inattentiveness and a lack of facility-specific knowledge contributed to this event. He also reported that because of budget cuts the facility no longer has a permanently assigned millwright and relies upon an outside organization to provide craft support. Therefore, he directed that facility personnel who oversee maintenance activities must ensure that they provide the appropriate degree of guidance for each craft person's experience level and facility knowledge. The facility manager also directed the maintenance support organization to ensure that the skill level and facility knowledge for craft support personnel match the specific activity and facility involved.

Weekly Summary 97-33 reported that in July 1997, the manager for the DOE Savannah River Operations Office released the findings for the Type B accident investigation of the plutonium intake by a crane operator at the Savannah River Site F-Canyon. The Board's findings were associated with selected peripheral work activities in radiological areas in F-Canyon. The work included area decontamination, jumper-gasket replacement, installation and removal of radiological huts, waste handling, and general housekeeping. These activities were routinely performed without supervision, were not perceived to require a high technical skill level, and did not normally receive management attention. During the course of the investigation, the Board found numerous examples of individuals failing to adhere to established requirements for peripheral work in radiological areas. The Board concluded that this was because peripheral work involved activities usually performed without supervision and not perceived to require a high technical skill level. Workers followed generic procedures that provided little guidance or direction because the nature of the work was perceived as not requiring direction or as depending on "skill of the craft." Peripheral work received little or no management attention because of its routine nature. (ORPS Report SR--WSRC-FCAN-1997-0009 and Type B Accident Investigation Board Report of the Plutonium Intake by a Crane Operator at the Savannah River Site F-Canyon)

These events illustrate the importance of personnel training and the necessity for facility managers to ensure that contractors understand and follow work control programs. The probability of error increases with the use of poor or incomplete procedures. Procedures should provide technical guidance to workers to help ensure that work is accomplished in a systematic and correct manner. This guidance must be technically accurate, complete, and up-to-date and must be presented in a clear, concise, and consistent manner that minimizes human error. Facility managers are ultimately responsible for ensuring successful completion of work activities. Routine monitoring of contractor and subcontractor work by facility managers and supervisors will help ensure that maintenance activities are conducted in accordance with facility policy and procedures.

Many DOE Orders, standards, and guidelines addressing training, conduct of operations, preventive maintenance, and the adequacy of technical staff are applicable to this event. Facility personnel responsible for work that is performed by maintenance personnel should clearly understand their responsibilities. Facility managers should ensure that work controls are rigorous enough to allow workers to complete jobs safely and efficiently without relying solely on skill of the craft.

- DOE O 4330.4B, *Maintenance Management Program,* chapter 15, "Management Involvement," identifies the degree of management involvement in oversight and approval of maintenance activities. Chapter II, section 8.3.1, "Work Control

Procedure," states that work control procedures help personnel understand the necessary requirements and controls. Section 8.3.6, "Control of Non-facility Contractor and Subcontractor Personnel," states that contractor and subcontractor personnel who perform maintenance or modifications on facility systems should be trained and qualified for the work they are to perform. This section also states that contractor and subcontractor personnel should receive training on (1) facility administration, (2) safety, (3) quality control, (4) radiation protection procedures and practices, and (5) general employee training.

- DOE O 5480.20, *Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Non-Reactor Nuclear Facilities,* states that the purpose of the Order is to assure that all persons are qualified to carry out their assigned responsibilities. Chapter I, sections 7.a.(1) and 7.a.(2), provide requirements for developing and maintaining training to meet the position requirements. Training department personnel also need to rigorously apply the principles and requirements of a systematic approach to training (for example, performance-based training) as defined in chapter I.7.b of the Order. This chapter provides a discussion of elements that contribute to a successful program for initial and continuing training. Requirements for initial and continuing training can be found in chapters I.7.c and I.7.d.

- DOE-STD-1050-93, *Guideline to Good Practices for Planning, Scheduling and Coordination of Maintenance at DOE Nuclear Facilities*, section 3.1.1.3, provides the key elements of an effective planning program. Included is guidance on consistency in planning between disciplines to avoid confusion and frustration in work groups. The standard also discusses the need for thorough reviews of work packages by experienced individuals to eliminate errors.

- DOE-STD-1051-93, *Guideline to Good Practices for Maintenance Organization and Administration at DOE Nuclear Facilities*, section 2.3.8, "Non-Facility Personnel," states that when non-facility personnel are used, the duties, authorities, responsibilities, and functional interfaces with personnel should be clearly defined.

KEYWORDS: maintenance, training and qualification

FUNCTIONAL AREAS: Training and Qualification, Mechanical Maintenance